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Application No.	Country	Date Filed
268546/1994	Japan	November 1, 1994

The undersigned declares further that all statements made herein of his/her own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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(Name of Article)	Specification	1
(Name of Article)	Drawing	1
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[NAME OF DOCUMENT] Specification

[TITLE OF THE INVENTION] Stage Unit

[WHAT IS CLAIMED IS]

[Claim 1]

A stage unit for a scanning exposure apparatus which scans a mask in a predetermined scanning direction and scans synchronously a photosensitive substrate in a scanning direction corresponding to said predetermined scanning direction while illuminating said mask on which a transfer pattern is formed thus exposing said pattern on said mask sequentially onto said substrate wherein said stage unit is provided for scanning an target scanning object consisting of said mask or said photosensitive substrate, said unit stage comprising:

a base;

a scanning stage arranged to be freely moved in said scanning direction on said base;

a fine adjustment stage, arranged to be freely moved within predetermined ranges in the scanning direction of said target scanning object and non-scanning direction perpendicular to said scanning direction with respect to said scanning stage, for mounting said target scanning object thereon;

a first electromagnetic actuator for driving said fine adjustment stage in the non-scanning direction with respect to said scanning stage; and

a second electromagnetic actuator for driving said fine adjustment stage in the scanning direction with respect to said scanning stage with a larger thrust than that of said first electromagnetic actuator.

[Claim 2]

A stage unit according to claim 1, wherein each of said first and the second electromagnetic actuators is of moving magnet type with a stationary member having a coil being fixed to said scanning stage; and said stage unit comprising a cooling unit for cooling each of said stationary members of said first and second electromagnetic actuators by circulating a predetermined cooling fluid.

[Claim 3]

A stage unit according to claim 2 further comprising a movable mirror fixed on said fine adjustment stage, and an interferometer for irradiating a measurement light beam on said movable mirror to detect a displacement of said fine adjustment stage with respect to said scanning stage,

wherein said cooling unit circulates said cooling fluid from a portion near an optical path of the light beam from said interferometer.

[Claim 4]

A stage unit according to claim 1, 2, or 3, wherein one of said first and second actuators is constituted by a

pair of electromagnetic actuators which are parallelly arranged.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Industrial Applicability]

The present invention relates to a stage unit mainly for an exposure apparatus, particularly relates to a stage unit applicable to reticle stage or wafer stage of the exposure apparatus of step-and-scan type for the manufacture of semiconductor devices.

[0002]

[Prior Art]

To manufacture semiconductor elements, liquid crystal display elements, or the like by using the photolithography technique, a projection exposure apparatus is conventionally used, in which a pattern formed on a reticle (or a photomask) is exposed, through a projection optical system, onto a wafer (or a glass plate) coated with a photoresist.

[0003]

In recent years, one chip pattern of a semiconductor element or the like tends to become larger. For this reason, a projection exposure apparatus for exposing a pattern on a reticle, which has a larger size, onto a wafer is required. To meet such a requirement for increasing the exposure area with a so-called step and

repeat type projection exposure apparatus for performing full exposure of the entire pattern on the reticle, the projection optical system must be made larger. However, this results in an increase in manufacturing cost of a projection optical system having high imaging performance on the entire surface of the wide exposure field.

[0004]

Therefore, a so-called step and scan type scanning exposure apparatus has received a great deal of attention. In this apparatus, after each shot area of the wafer is moved to the scan start position, the reticle, which is being illuminated, is scanned in a direction crossing the optical axis of the projection optical system. In synchronism with this scanning, the wafer is scanned in the direction crossing the optical axis of the projection optical system, thereby exposing the pattern of the reticle onto each shot area of the wafer.

[0005]

Fig. 4 is a view schematically showing the arrangement of a conventional scanning exposure apparatus. Referring to Fig. 4, an illumination light beam IL from an optical integrator (not shown) in an illumination optical system illuminates a field stop 2 through a first relay lens 1. The illumination light beam

passing through the slit-like opening of the field stop 2 illuminates a slit-like illumination area 7 on a reticle 6 at a uniform illuminance through a second relay lens 3, a mirror 4 for deflecting the optical path, and an illumination condenser lens 5. The arrangement surface of the field stop 2 is conjugate with the pattern formation surface of the reticle 6. The projected image of the rectangular opening formed in the field stop 2 and having a width d_s of the short side corresponds to the slit-like illumination area 7.

[0006]

The pattern image of the reticle 6 in the illumination area 7 is formed and projected in a slit-like exposure area 18 on a wafer 17 through a projection optical system 14 which is telecentric on both the sides (or telecentric on one side). The Z axis is set parallel to the optical axis of the projection optical system 14. The X axis is set perpendicular to the sheet surface of Fig. 4 in a plane perpendicular to the Z axis. The Y axis is set parallel to the sheet surface of Fig. 4. The scanning direction is parallel to the Y axis.

[0007]

The reticle 6 is held on a fine adjustment stage 8. The fine adjustment stage 8 is movably and rotatably mounted on a scanning stage 9 in the X-Y plane. The

scanning stage 9 is mounted on a reticle base 10 so as to be driven by a linear motor (not shown) in the Y direction (or in the -Y direction) as the scanning direction. The coordinate values of the fine adjustment stage 8 along the scanning and non-scanning directions, which are measured by a movable mirror 11 fixed at the end portion on the fine adjustment stage 8 and a laser interferometer 12 arranged outside, are supplied to a main control system 13. The main control system 13 controls the position of the fine adjustment stage 8 and the scanning speed of the scanning stage 9 on the basis of the supplied coordinate values.

[0008]

On the other hand, the wafer 17 is mounted on an X stage 20 through a wafer holder 19. The X stage 20 is mounted on a Y stage 21 so as to be freely driven by a driving motor 27 in the X direction. The Y stage 21 is mounted on a unit base 22 so as to be freely driven by a driving motor 25 and a feed screw 26 in the Y direction. A Z stage for adjusting the portion of the wafer 17 along the Z direction, a leveling stage (not shown) for adjusting the inclination angle of the wafer 17, and the like are mounted on the X stage 20. The two-dimensional coordinate values of the X stage 20, which are measured by a movable mirror 23 fixed on the X stage 20 and a laser interferometer 24 arranged

outside, are supplied to the main control system 13. The main control system 13 controls the operations of the driving motors 25 and 27 on the basis of the supplied coordinate values.

[0009]

In scanning exposure, when the projection magnification of the projection optical system 14 is defined as β, the scanning stage 9 on the reticle side is scanned in a direction indicated by an arrow B1 at a speed V_R under the control of the main control system 13. In synchronism with this scanning, the Y stage 21 on the wafer side is scanned in a direction indicated by an arrow C1 at a speed V_W (= βV_R), thereby sequentially projecting and exposing the pattern image of the reticle 6 onto the wafer 17.

[0010]

Fig. 5 is a perspective view showing synchronous scanning. Referring to Fig. 5, a pattern area 15 of the reticle 6 is scanned in the direction indicated by the arrow B1 with respect to the hatched slit-like illumination area 7. In synchronism with this scanning, a shot area 16 of the wafer 17 is scanned in the direction indicated by the arrow C1 with respect to the hatched exposure area 18. With this operation, the pattern image in the pattern area 15 of the reticle 6 is sequentially exposed onto the shot area 16.

[0011]

Fig. 6 is a plan view of the reticle stage in Fig. 4. Fig. 7 is a side view of the reticle stage. As shown in Fig. 6, the scanning stage 9 is mounted to be moved in the Y direction along linear guides 34A and 34B on the reticle base 10, which are parallel to the Y axis. A first linear motor 31A is constituted by a stationary member 33A and a movable member 32A while a second linear motor 31B is constituted by a stationary member 33B and a movable member 32B. The stationary members 33A and 33B are fixed on the reticle base 10 to be parallel to the linear guides 34A and 34B. The movable members 32A and 32B are fixed to the scanning stage 9 along the stationary members 33A and 33B. The scanning stage 9 is driven by the two linear motors 31A and 31B in the +Y or -Y direction with respect to the reticle base 10.

[0012]

As shown in Fig. 7, the fine adjustment stage 8 is mounted on the scanning stage 9. The fine adjustment stage 8 can be finely moved by a driving system (not shown) in the X and Y directions with respect to the scanning stage 9 and also can be finely rotated in the θ direction on the scanning stage 9.

As for a method of driving the fine adjustment stage of this type, three mechanical systems for converting the

rotational movement of a servo motor into a linear movement are used, and the fine adjustment stage is moved by the three mechanical systems in the X, Y, and θ directions.

[0013]

A system using an electromagnetic actuator is also proposed as a two-dimensional stage driving system (e.g., Japanese Patent Laid-Open No. 2-35709). In this system, thrusts in the two driving directions are equal to each other. Additionally, the system is heavy, and no countermeasure is made against deformation due to heat generation.

[0014]

[Problems to be Solved by the Invention]

However, in the fine adjustment stage using such an electromagnetic actuator, the thrusts and shapes of two electromagnetic actuators for moving the fine adjustment stage in the two directions are equal regardless of the driving directions. Particularly, although the scanning exposure apparatus requires a smaller thrust to move the fine adjustment stage in a non-scanning direction than in the scanning direction, an electromagnetic actuator having an excessive thrust is used. Therefore, the fine adjustment stage becomes heavy, and the heat generation amount also increases.

[0015]

When the fine adjustment stage becomes heavy, the natural frequency becomes lower, so the response speed cannot be increased. In addition, the fine adjustment stage is deformed due to heat generation of the coil of the electromagnetic actuator, resulting in a degradation in accuracy of the reticle holding surface or the reflecting mirror holding surface. Furthermore, heat generation of the coil degrades the measurement precision of the measurement system such as an interferometer for detecting the position of the fine adjustment stage. For example, when an interferometer is used, heat generation of the coil causes an increase in ambient temperature, which causes variations or fluctuations in temperature of air on the optical path of the interferometer, resulting in an error in measurement value.

[0016]

In order to solve the above mentioned problems, an object of the present invention is to provide a stage unit suitable for an scanning exposure apparatus wherein the weight of the fine adjustment stage is reduced and the fine adjustment stage as well as the measurement system are not effected by the heat generated by the driving system.

[0017]

[Means for Solving the Problems]

According to the present invention, there is provided a stage unit arranged in a scanning exposure apparatus which illuminates a mask on which a transfer pattern is formed, scans the mask in a predetermined scanning direction (Y direction or -Y direction), and synchronously scans a photosensitive substrate in a direction corresponding to the predetermined scanning direction, thereby sequentially exposing the pattern of the mask onto the photosensitive substrate, comprising a base (10), a scanning stage (9) arranged to be freely moved in the scanning direction on the base, a fine adjustment stage (8) arranged to be freely moved, with respect to the scanning stage, within predetermined ranges in the scanning direction of a target scanning object and a non-scanning direction (X or -X direction) perpendicular to the scanning direction, for mounting the target scanning object thereon, a first electromagnetic actuator (42A, 42B) for driving the fine adjustment stage (8) in the non-scanning direction with respect to the scanning stage (9), and a second electromagnetic actuator (39A, 39B) for driving the fine adjustment stage (8) in the scanning direction with respect to the scanning stage (9) with a larger thrust than that of the first electromagnetic actuator (42A, 42B).

[0018]

In this case, as each of the first and second electromagnetic actuators (42A, 42B, 39A, 39B), an electromagnetic actuator of a moving magnet type in which a stationary member (41A, 41B, 38A, 38B) having a coil is fixed on the scanning stage side (9) is used. Cooling means (53 to 55, 56a to 56C) for cooling the stationary member (41A, 41B, 38A, 38B) of each of the first and second electromagnetic actuators (42A, 42B, 39A, 39B) by circulating a predetermined cooling fluid (63) is preferably arranged.

[0019]

In addition, a movable mirror (48A, 48B, 51) fixed on the fine adjustment stage (8), and an interferometer (47A, 47B, 50) for irradiating a measurement light beam on the movable mirror to detect a displacement of the fine adjustment stage (8) with respect to the scanning stage (9) are provided. The cooling means (53 to 55, 56a to 56c) preferably circulates the cooling fluid (63) from a portion near an optical path (49A, 49B, 52) of the light beam from the interferometer (47A, 47B, 50).

[0020]

Furthermore, one of the first and second electromagnetic actuators (42A, 42B, 39A, 39B) is preferably constituted by a pair of electromagnetic actuators (39A, 39B or 42A, 42B) which are parallelly

arranged.

[0021]

[Function]

In the scanning exposure apparatus using the stage unit according to the present invention, a large inertial force in the scanning direction is applied to the fine adjustment stage particularly at the start and end of scanning, while an actuator having a small thrust is used as the electromagnetic actuator (42A, 42B) for driving the fine adjustment stage 8 in the non-scanning direction (X direction or -X direction) because the inertial force applied to the fine adjustment stage in the non-scanning direction can be almost neglected. With this arrangement, the shape and weight of the movable member (40A, 40B) of the electromagnetic actuator can be reduced. For this reason, the overall weight of the fine adjustment stage (8) is reduced, thereby improving the control performance of the stage. In addition, the capacity of the coil of the electromagnetic actuator (42A, 42B) in the non-scanning direction can also be reduced. Since a heat generation amount from the coil is also decreased, heat deformation of each stage (8, 9, 10) is minimized, thereby minimizing the adverse influence of heat to the measurement equipment for position measurement.

[0022]

When each of the first and second electromagnetic actuators (42A, 42B, 39A, 39B) is an electromagnetic actuator of a moving magnet type, and the cooling means (53, 54, 55, 56a, 56b, 56c) for cooling the stationary member (41A, 41B, 38A, 38B) of each of the first and second electromagnetic actuators by circulating the predetermined cooling liquid (63) is arranged, the fine adjustment stage (8) is separated from the coil as a heat source. For this reason, the heat deformation of the fine adjustment stage (8) can be minimized as compared to a case wherein an electromagnetic actuator of a moving coil type is used.

[0023]

When the stationary member (38A, 38B, 41A, 41B) as a heat source is liquid-cooled, the total heat generation amount is minimized. It is mechanically easy to cool the stationary member in this manner.

The movable mirror (48A, 48B, 51) fixed on the fine adjustment stage (8), and the interferometer (47A, 47B, 50) for irradiating the measurement light beam on the movable mirror to detect the displacement of the fine adjustment stage (8) with respect to the scanning stage (9) are arranged, and the cooling fluid (63) is circulated from the portion near the optical path (49A, 49B, 52) of the light beam from the interferometer. In this case, when the cooling fluid (63) has the largest

cooling capability, the electromagnetic actuators are sequentially cooled from the portion (42B) near the optical path. For this reason, temperature adjustment of a gas on the optical path is stably performed, thereby maintaining a high measurement precision.

[0024]

When one of the first and second electromagnetic actuators (39A, 39B, 42A, 42B) is constituted by a pair of electromagnetic actuators (39A, 39B, or 42A, 42B) which are parallelly arranged, driving in the rotational direction is enabled by applying thrusts to the pair of electromagnetic actuators in opposite directions in addition to driving in scanning and non-scanning directions.

[0025]

[Embodiment]

An embodiment of the stage unit according to the present invention will be described below with reference to Figs. 1 to 3. In this embodiment, the present invention is applied to the reticle stage of a step and scan type projection exposure apparatus. The same reference numerals as in Figs. 4 to 7 denote the same parts in Figs. 1 to 3, and a detailed description thereof will be omitted.

[0026]

Fig. 1 is a plan view of the reticle stage of this

embodiment. Referring to Fig. 1, a scanning stage 9 is mounted on a base 10 to be slidable in the Y direction along linear guides 34A and 34B. The scanning stage 9 is driven by linear motors 31A and 31B in the +Y or -Y direction with respect to the reticle base 10. A Y axis movable mirror 45 is fixed at the end portion of the scanning stage 9 in the Y direction. A laser beam from an external laser interferometer 44 is irradiated on the movable mirror 45 to be parallel to the Y axis, as indicated by an optical path 46. The Y coordinate of the scanning stage 9 is obtained from the measurement value from the laser interferometer 44.

[0027]

A fine adjustment stage 8 is mounted on the scanning stage 9 to be finely moved by a driving system (to be described later) in the X and Y directions and in the rotational direction (θ direction). A reticle 6 (Fig. 2) having an original pattern is held, by, e.g., vacuum suction, on the fine adjustment stage 8 having an opening (not shown) at the central portion. An exposure illumination light beam from an illumination optical system (not shown) is irradiated on a slit-like illumination area in the pattern formation area on the lower surface of the reticle. In scanning exposure, the reticle is scanned through the scanning stage 9 at a predetermined speed in the +Y or -Y direction as the

short side direction of the illumination area. Position adjustment is performed by the fine adjustment stage 8 as needed.

[0028]

Y axis movable mirrors 48A and 48B are fixed at the end portion of the fine adjustment stage 8 in the Y direction. Laser beams from external laser interferometers 47A and 47B are irradiated on the movable mirrors 48A and 48B to be parallel to the Y axis, as indicated by optical paths 49A and 49B respectively. The Y coordinate of the fine adjustment stage 8 is obtained from the average value of the measurement values from the interferometers 47A and 47B. The rotation angle of the fine adjustment stage 8 is obtained from the difference between the measurement values from the interferometers 47A and 47B. An X axis movable mirror 51 is fixed at the end portion of the fine adjustment stage 8 in the X direction. A laser beam from an external laser interferometer 50 is irradiated on the movable mirror 51 to be parallel to the X axis, as indicated by an optical path 52. The X coordinate of the fine adjustment stage 8 is obtained from the measurement value from the laser interferometer 50. The position of the scanning stage 9 along the Y direction and the scanning speed are controlled on the basis of the X coordinate, the Y

coordinate, and the rotation angle, which are obtained in the above manner, and the position and the rotation angle of the fine adjustment stage 8 are simultaneously controlled.

[0029]

As shown in Fig. 2, a plurality of spherical rollers (only rollers 43A and 43B are illustrated in Fig. 2) are arranged between the fine adjustment stage 8 and the scanning stage 9. The fine adjustment stage 8 is smoothly moved on the plane of the scanning stage 9 through these rollers 43A and 43B.

The driving system of the fine adjustment stage 8 will be described below in detail.

[0030]

As shown in Figs. 1 and 2, electromagnetic actuators 39A and 39B each constituted by a moving magnet type (MM type) linear motor for mainly driving the fine adjustment stage 8 in the Y direction as the scanning direction in scanning exposure are provided on the side surfaces of the fine adjustment stage 8 in the +X and -X directions, respectively. The electromagnetic actuator 39A is constituted by a movable member 37A fixed on the side surface of the fine adjustment stage 8 in the +X direction and a stationary member 38A fixed to the scanning stage 9. When a current flows through the stationary member 38A incorporating a coil, a

linear force is applied to the movable member 37A incorporating a magnet, thereby moving the movable member 37A in the Y or -Y direction. When the current inversely flows, the moving direction is reversed. All electromagnetic actuators used to drive the fine adjustment stage 8 in this embodiment are MM type linear motors and similarly operate.

[0031]

The fine adjustment stage 8 is driven in the +Y, the -Y, or the rotational direction by the electromagnetic actuator 39B constituted by a movable member 37B fixed on the side surface of the fine adjustment stage 8 in the -X direction and a stationary member 38B fixed to the scanning stage 9, and the above electromagnetic actuator 39A. Driving in the rotational direction is performed within a range not to bring the movable members 37A and 37B into contact with the stationary members 38A and 38B.

[0032]

Electromagnetic actuators 42A and 42B for mainly driving the fine adjustment stage 8 in the X direction as the non-scanning direction perpendicular to the scanning direction are arranged on the side surfaces of the fine adjustment stage 8 in the -Y and +Y directions, respectively. The electromagnetic actuator 42A is constituted by a movable member 40A fixed on the

side surface of the fine adjustment stage 8 in the -Y direction and a stationary member 41A fixed to the scanning stage 9. The electromagnetic actuator 42B is constituted by a movable member 40B fixed on the side surface of the fine adjustment stage 8 in the +Y direction and a stationary member 41B fixed to the scanning stage 9. The fine adjustment stage 8 is driven by the electromagnetic actuators 42A and 42B in the +X, the -X, or the rotational direction.

[0033]

Both of the electromagnetic actuators 42A and 42B have a thrust smaller than that of the electromagnetic actuators 39A and 39B used for the scanning direction. The operations of the electromagnetic actuators and the fine adjustment stage 8 will be briefly described below. While the scanning stage 9 is moving in the scanning direction at a constant speed, the fine adjustment stage 8 can be driven in the X direction by applying a thrust to the two electromagnetic actuators 42A and 42B in the same direction. Similarly, the fine adjustment stage 8 can be driven in the Y direction by applying a thrust to the two electromagnetic actuators 39A and 39B in the same direction.

[0034]

In addition, the fine adjustment stage 8 can be rotated by applying thrusts in the opposing directions to the

two electromagnetic actuators 42A and 42B that drive the fine adjustment stage 8 in the X direction. The electromagnetic actuators 39A and 39B in the Y direction also similarly operate.

When the scanning stage 9 is accelerated/decelerated in the scanning direction (Y direction) in scanning exposure, a large inertial force is generated to the fine adjustment stage 8 in the Y direction by this acceleration. However, this inertial force can be canceled by the thrusts of the electromagnetic actuators 39A and 39B, thereby setting the relative speed between the fine adjustment stage 8 and the scanning stage 9 to zero. A thrust required to cancel the inertial force in the scanning direction (Y direction) is larger than that required in the non-scanning direction (X direction) perpendicular to the scanning direction. As the electromagnetic actuators 39A and 39B, large actuators having larger thrusts are used.

[0035]

In this embodiment, a cooling means for removing heat generated from the electromagnetic actuators 39A, 39B, 42A, and 42B are provided. This cooling means will be described below with reference to Figs. 1 and 3.

Referring to Fig. 1, the stationary members 38A, 38B, 41A, and 41B of the electromagnetic actuators 39A, 39B,

42A, and 42B are arranged in a circulating cooling path (to be described later), and cooled by a cooling fluid adjusted to a predetermined temperature by a liquid cooling temperature adjustment unit 53 and supplied from an internal circulating pump. The circulating cooling path starting from the liquid cooling temperature adjustment unit 53 is sequentially serially constituted by a cooling fluid circulating tube 54, the stationary member 41B, a cooling fluid circulating tube 56a, the stationary member 38B, a cooling fluid circulating tube 56b, the stationary member 41A, a cooling fluid circulating tube 56c, the stationary member 38A, a cooling fluid circulating tube 55, returning to the liquid cooling temperature adjustment unit 53. The cooling fluid starts to flow from the cooling fluid circulating tube 54 near the optical path 49A of the laser interferometer, and passes through the cooling fluid circulating tube 56a near the optical path 49B of the laser interferometer and immediately through the stationary member 38B near the optical path 52 of the laser interferometer. Therefore, the temperature in the optical paths 49A, 49B, and 52 of the laser interferometers is precisely maintained at a predetermined level.

[0036]

Fig. 3 is a sectional view of the electromagnetic

actuator 42B in Fig. 2 along a plane parallel to the sheet surface of Fig. 2. As shown in Fig. 3, the stationary member 41B is constituted by a base 60, a hollow cover 61 fixed on the base 60, and a coil 62 accommodated in the cover 61. In this case, to cool the coil 62, a cooling fluid 63 flows between the coil 62 and the cover 61. If the coil 62 has satisfactory insulating properties, e.g., water can be used as the cooling fluid 63. However, as the cooling fluid 63, a fluid having no corrosiveness against the coil 62 and the cover 61, no conductivity, and no chemical inertness is preferable. In this embodiment, therefore, e.g., a fluorine-based inert fluid is used as the cooling fluid 63.

[0037]

On the other hand, the movable member 40B is constituted by fixing a pair of magnets 64 and 65 to a fixing plate 65 above the stationary member 41B such that the stationary member 41B is sandwiched therebetween. That is, the electromagnetic actuator 42B of this embodiment is of a moving magnet type having magnets incorporated in the movable member 41B. In this case, since the coil 62 as a main heat source is incorporated on the stationary member 41B side, the coil 62 can be easily cooled. The remaining electromagnetic actuators 39A, 39B, and 42A also have

the same arrangement.

[0038]

As described above, when electromagnetic actuators having the same thrust regardless of the scanning direction and non-scanning direction are used, an actuator having an excessive thrust is used as the electromagnetic actuator for applying a thrust in the non scanning direction. As a result, the entire stage becomes heavy to cause an increase in cost. In this embodiment, however, electromagnetic actuators having appropriate thrusts in the scanning direction and non-scanning direction are used. As a result, the weight of the entire stage is decreased, the heat generation amount is decreased, and cost is reduced.

[0039]

According to this embodiment, cooling is efficiently performed by circulating the heat absorption fluid without leaking the heat mainly generated in the coil in the stationary member of the electromagnetic actuator to the scanning stage 9, the fine adjustment stage 8, and the like as radiated heat, or conducted heat. In addition, the influence of the temperature or the fluctuation of air with respect to the laser beams can be minimized.

[0040]

In this embodiment, a linear motor is used as the

electromagnetic actuator. Even if a voice coil motor is used in place of the linear motor, the same effect can be obtained. In this embodiment, the electromagnetic actuators are serially connected and cooled. However, the electromagnetic actuators can also be parallelly cooled. The parallel cooling method is advantageous in that the electromagnetic actuators can be cooled under the same conditions. However, this method has a difficulty in control because piping becomes complex, and if a single temperature adjustment unit is used, the cooling fluid flows toward a lower pressure.

[0041]

In this embodiment, the stage unit of the present invention is applied to the reticle stage used in a step and scan type projection exposure apparatus. However, the stage unit of the present invention can also be applied to the wafer stage in addition to the reticle stage.

The present invention is not limited to the above described embodiment but can be any modification without a departure from the scope of the spirit of the present invention.

[0042]

[Effects of the Invention]

According to the stage unit of the present invention,

since an actuator having a small thrust is used for the driving in the non-scanning direction in the scanning exposure, the weight of the fine adjustment stage can be reduced, thereby the control performance of the stage can be improved due to the high natural frequency. In addition, a heat generation amount from the coil is also decreased since the thrust of the electromagnetic actuator becomes smaller, thus heat deformation of the stages, mainly the fine adjustment stage and the bad effect on the measurement accuracy of measurement equipment such as the interferometer can be reduced.

[0043]

When each of the first and second electromagnetic actuators is an electromagnetic actuator of a moving magnet type, and the cooling means for cooling the stationary member of each of the first and second electromagnetic actuators by circulating the predetermined cooling liquid is arranged, the distance of the fine adjustment stage from the heat source (coil) becomes longer thus heat deformation of the fine adjustment stage can be minimized as compared to a case wherein an electromagnetic actuator of a moving coil type is used. Further the cooling of the stationary members becomes easier from viewpoint of the structure.

[0044]

The movable mirror fixed on the fine adjustment stage, and the interferometer for irradiating the measurement light beam on the movable mirror to detect the displacement of the fine adjustment stage with respect to the scanning stage are arranged, and the cooling fluid is circulated from the portion near the optical path of the light beam from the interferometer. In this case, temperature of gas on the optical path is adjusted stably, thereby reducing an error in measurement value obtained by the interferometer.

[0045]

When one of the first and second electromagnetic actuators is constituted by a pair of electromagnetic actuators which are parallelly arranged, driving in the rotational direction is enabled by applying thrusts to the pair of electromagnetic actuators in opposite directions.

[BRIEF DESCRIPTION OF DRAWINGS]

[Fig. 1]

A plan view showing an embodiment of a stage unit according to the present invention;

[Fig. 2]

A front view of the stage unit shown in Fig. 1;

[Fig. 3]

A sectional view of an electromagnetic actuator 42B shown in Fig. 2 along a plane parallel to the sheet

surface of Fig. 2;

[Fig. 4]

A view schematically showing the arrangement of a conventional scanning exposure apparatus;

[Fig. 5]

A perspective view for explaining synchronous scanning in the scanning exposure apparatus shown in Fig. 4;

[Fig. 6]

A plan view showing a reticle stage in Fig. 4; and

[Fig. 7]

A front view of the reticle stage shown in Fig. 5;

[Explanation of Symbols and Numerals]

8: fine adjustment stage

9: scanning stage

10: reticle base

37A, 37B: movable member

38A, 38B: stationary member

39A, 39B: electromagnetic actuator (for driving in scanning direction)

40A, 40B: movable member

41A, 41B: stationary member

42A, 42B: electromagnetic actuator (for driving in non-scanning direction)

47A, 47B, 50: interferometer

49A, 49B, 52: optical path of laser beam

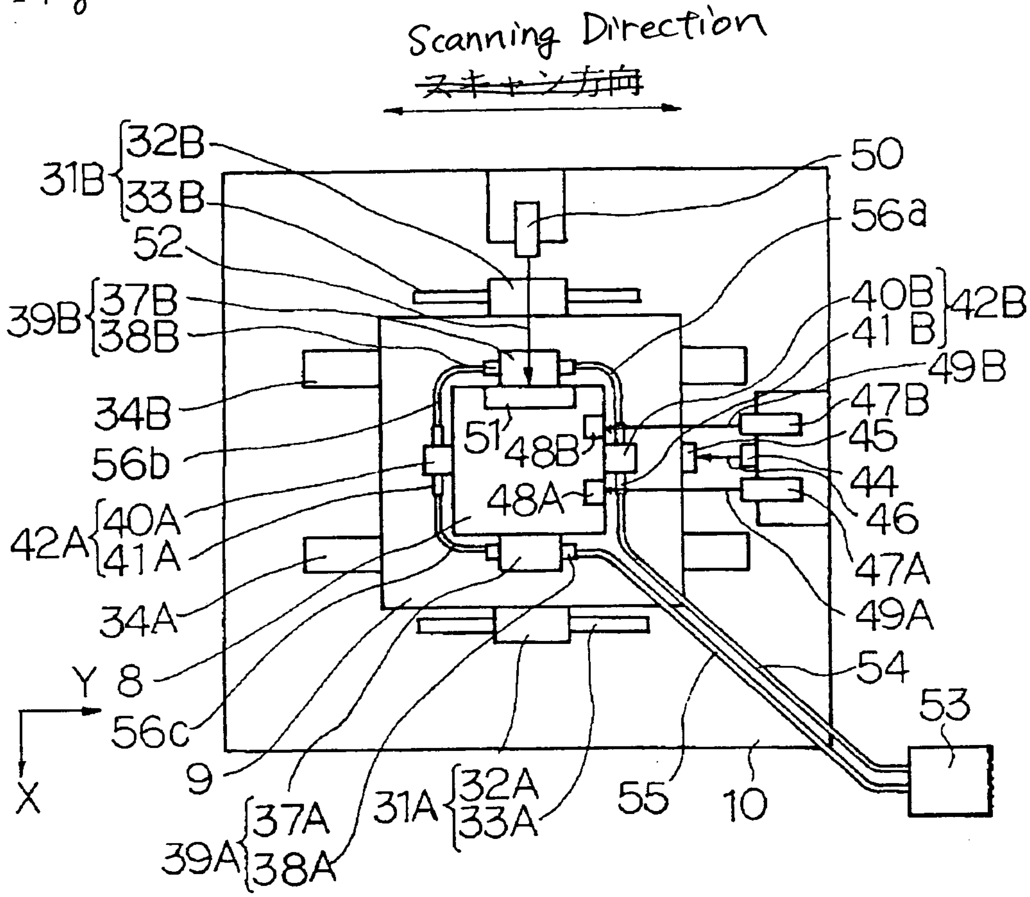
53: liquid cooling temperature adjustment unit

54, 55, 56a, 56b, 56c:

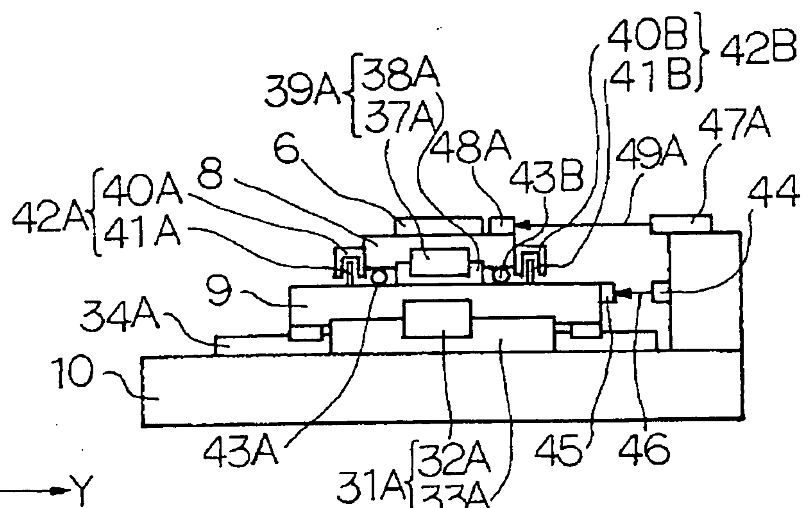
cooling fluid circulating tube

【書類名】　図面

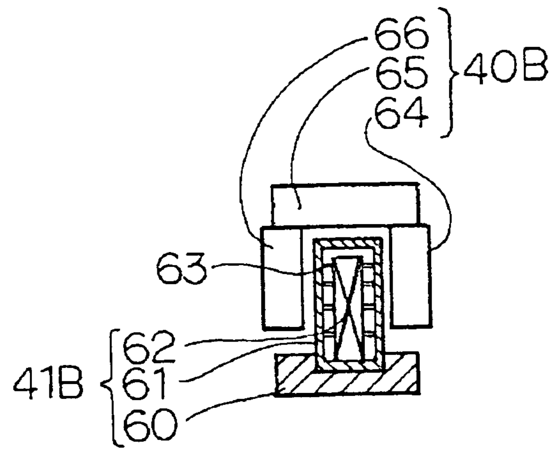
~~【図1】~~ Fig. 1



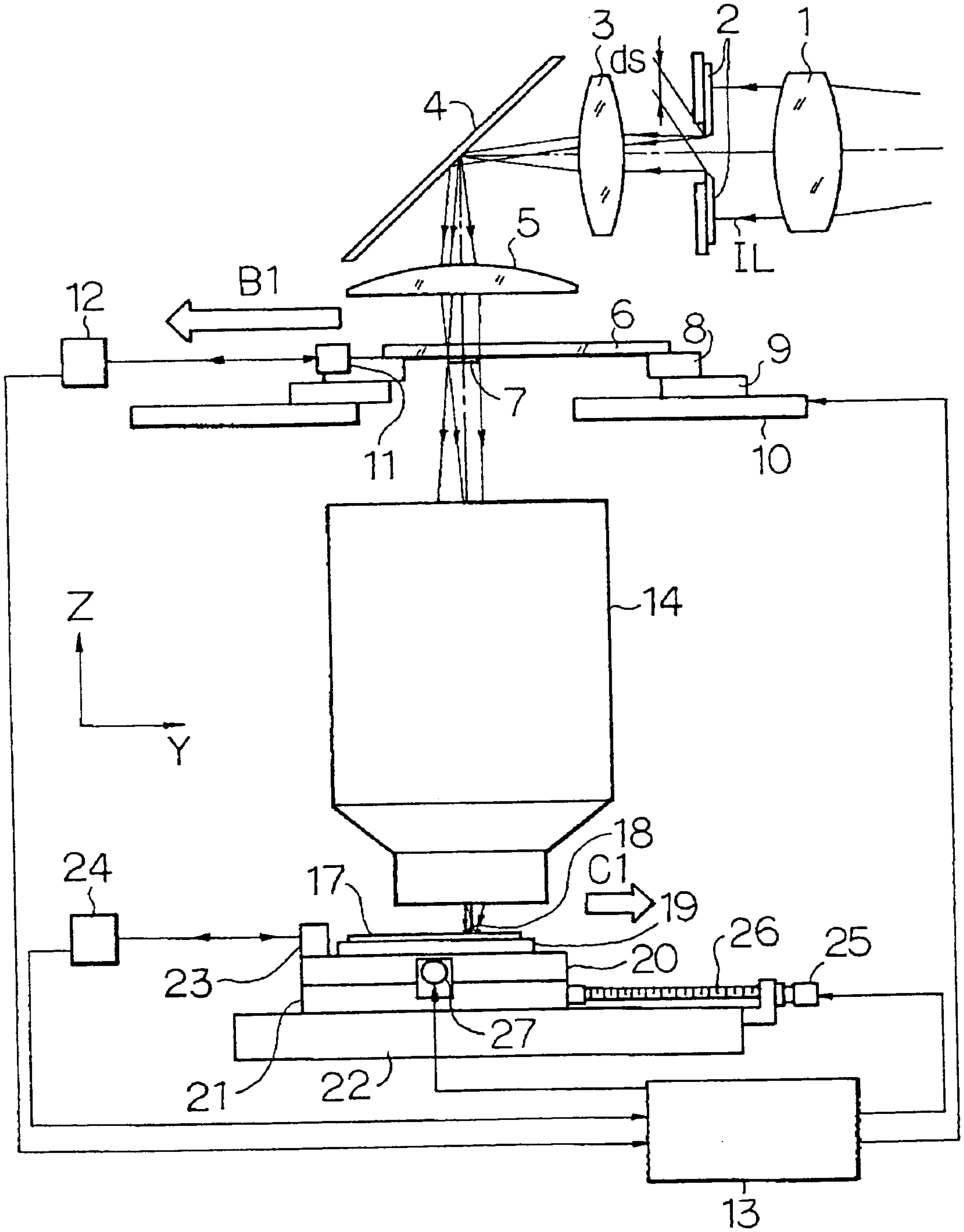
~~【図2】~~ Fig. 2



~~【図3】~~ Fig. 3



~~【図4】~~ Fig-4



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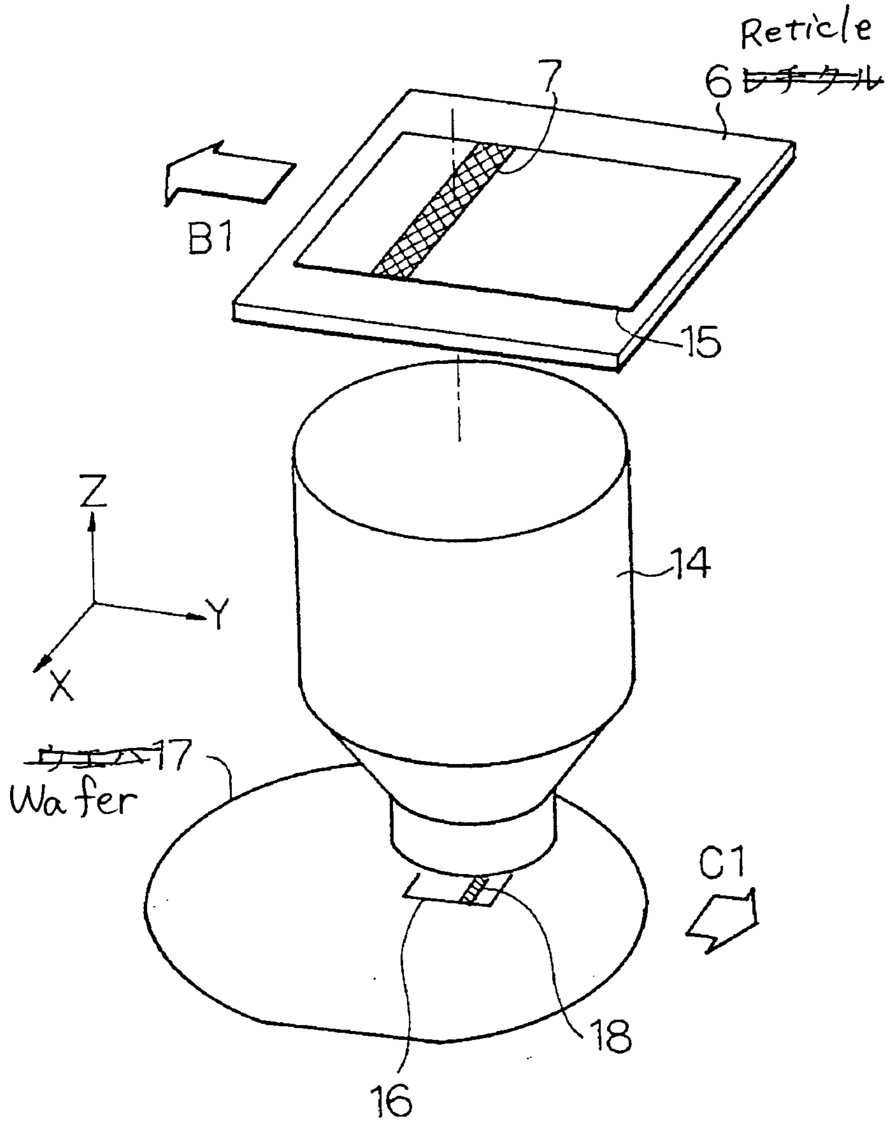
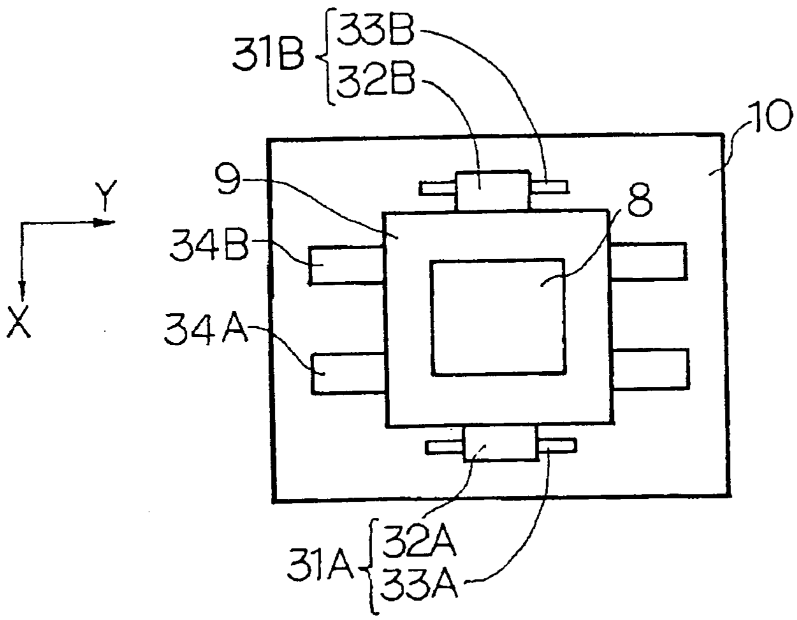
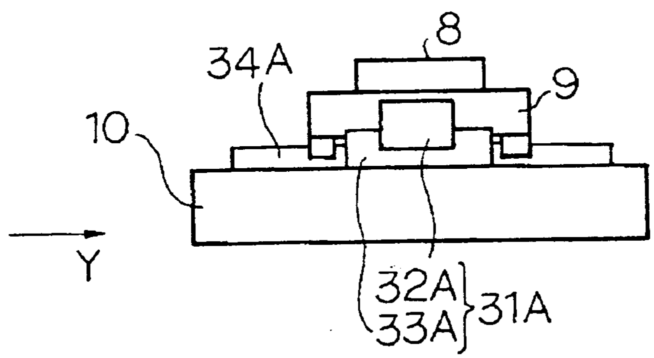
~~【図5】~~ Fig.5



~~【図6】~~ Fig. 6



~~【図7】~~ Fig. 7



[NAME OF DOCUMENT] Written Abstract

[ABSTRACT]

[OBJECT]

To reduce the weight of a stage unit for an scanning exposure apparatus which exposes a pattern on a mask to a photosensitive substrate via a projection optical system, restrain the heat generation from the driving unit of the stage, and improve the surface accuracy of the stage and the measurement accuracy of an interferometer for measuring the position of the stage.

[CONSTITUTION]

A stage unit comprises a reticle base 10 as a reticle stage; a scanning stage 9 mounted on the reticle stage for performing the movement in a scanning direction; a fine adjustment stage 8 mounted on the scanning stage for performing fine movement in X,Y directions and rotation direction; an electromagnetic actuator 39A, 39B for driving the fine adjustment stage 8 in the scanning direction; and electromagnetic actuator 42A, 42B for driving the fine adjustment stage in a non-scanning direction and having a thrust smaller than that of the electromagnetic actuator 39A, 39B.

[SELECTED DRAWING] Fig. 1